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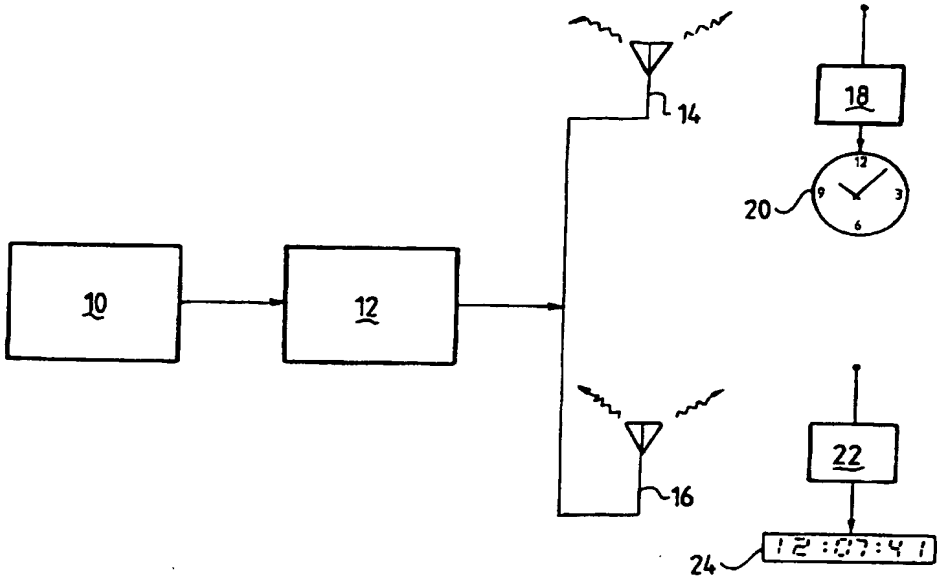
(54) Title: SYNCHRONIZATION OF A TIMEPIECE TO A REFERENCE TIME

(57) Abstract

A method and apparatus for synchronizing a timepiece to a reference time includes the preparation (10) of an encoded and/or encrypted signal for transmission from a paging network (12) transmitter (14, 16). The signal, which contains a time message and information on Daylight Saving changes and corrections to UTC time, is transmitted a number of times in a twenty-four hour period, with brief intervals between each transmission. A timepiece (18, 22) has a receiver and control circuitry (34) which receive and decode the signal. The decoded time information is used to automatically set the time of the timepiece (18, 22) to the correct time for a predetermined time zone. A locality switch is provided on the timepiece (18, 22) to determine which time zone time is to be displayed (20, 24). To correct for delays which may be encountered in queuing and transmission, a second signal may be transmitted as a result of the first signal being received by a monitor, the second signal including information about the time of receipt of the first signal by the monitor, such that the timepiece, upon receipt of the second signal, is able to correct for any delays, and to then display accurate time. To correct for the possibility that data may be corrupted, updates may not take place until a third signal is transmitted. A master unit located in the paging network coverage area, which has a source of accurate time, receives the time update and determines that the updated time is correct or incorrect. If it is correct, the third signal will be a "confirmation" signal. If the updated time is incorrect, the third signal will be an "ignore" signal.



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SYNCHRONIZATION OF A TIMEPIECE TO A REFERENCE TIME

This invention relates to improvements in the synchronization of a timepiece to a reference time, and in particular, relates to an improved method and apparatus for synchronizing a timepiece to such a time.

In this specification, the term "timepiece" refers to a horological device for keeping and/or displaying time, and/or for generating a signal which in turn may result in a display of time.

Timekeeping devices have been in use for some 3,500 years. Mechanical timepieces have been in existence for 900 years, and clocks have been known since the fourteenth century.

Every location on a particular degree of longitude has the same local time, and it follows that such a location has a slightly different time from that in a town or village a few kilometres to the east or west. In the days before improved communications and transport, such places were isolated, and there was no need to impose any time standard. With the coming of the railways, and subsequently the telegraph, it became both necessary and possible to impose a single standard time for an entire country (such as the United Kingdom) or for each of a number of time zones extending across a country (such as the United States of America and Australia).

Australia is divided into three time zones: Eastern Standard Time [EST] (Queensland, New South Wales, the Australian Capital Territory, Victoria and Tasmania), Central Standard Time [CST] (South Australia and the Northern Territory) and Western Standard Time [WST] (Western Australia). Some States have adopted Daylight Saving, advancing clocks one hour ahead of the relevant Standard time for a period of some months between spring and autumn each year. Others have not, which results in there being up to five time zones in Australia during the period in which Daylight Saving operates. In the spring to autumn period of 1994/1995, a different set of five time zones was created by

the decisions of New South Wales and Victoria to return to Eastern Standard Time on different dates. New South Wales has subsequently agreed to use the same dates as Victoria and Tasmania for the end of Daylight Saving, however, there are still difficulties for persons, particularly business persons, in the various States and Territories which are normally in the one time zone.

Despite the problems caused by having between three and five time zones, and the twice-yearly change of the time régime in all but three of the eight States and Territories, most timepieces in Australia operate independently of each other, and require a manual operation to correct and change the time displayed, and day and date when applicable.

In Australia, Telstra Corporation is responsible for providing reference times, producing the "pips" heard on the hour (on the half-hour in South Australia and the Northern Territory) on some radio stations, providing the dial-up "speaking clock", and providing equivalent facilities for computer users via modems. Telstra also has a representative on the National Time Committee, although as has been mentioned earlier in this specification, the States have powers over such things as whether or not a particular State adopts Daylight Saving, and the entry and exit dates to and from Daylight Saving.

There are in existence in Australia installations of a plurality of clocks, operating on a "master-slave" basis, where a master clock is connected by electrical cabling to a number of slave clocks, which are controlled by the master clock and as a result all show the same time. Such installations may be found in locations such as hospitals and airport terminals. They are cumbersome, and expensive to construct, and are only useful where no slave clock is very far from the master clock.

The concept of using a radio signal to carry time information was first published some forty years ago. In US-A-4,204,398 by Lemelson, published on 27 May 1980, there is disclosed a method and apparatus for automatically setting timepieces in a time zone. The method involved the setting of a timepiece -

such as a watch worn by a traveller passing from one time zone to another – by the transmission of a time-related signal, which results in the timepiece displaying or being able to display the correct time for the time zone in which the timepiece is located.

AU-B-83677/91 (643824) by NEC Corporation, published on 12 March 1992, relates to time-keeping apparatus which utilises a cellular mobile communications system as a source of transmitted signals which cause a correct time to be displayed on a timepiece which is adapted to be mounted on a vehicle or to be personally carried.

The Federal Republic of Germany has in operation a system called the German Radio Clock. A powerful VLF transmitter broadcasts signals which are received by a large number of clocks throughout Europe (much of which operates on Central European Time), and which synchronizes those clocks, bringing each of them to the correct time.

There is clearly a need for a system in Australia and other countries which is able to remotely synchronize and reset timepieces. For example, it is essential to be able to maintain the correct time on timepieces – most of which have digital displays – which are associated with personal computers, cash registers, fax machines, automated teller machines (ATMs), debit and credit card terminals, and so on. This is particularly so for accurate records of such things as credit card transactions, ATM transactions, faxes sent and received, and so on, as well as dealing with the problems caused by Daylight Saving changes. Many of the present clocks used in such applications drift alarmingly over relatively short periods of time. In addition, there is rarely any structure in place to check and correct the time shown on such a timepiece; it is also quite common for such clocks to not be reset for and/or after Daylight Saving changes.

It is an object of this invention to provide an improved system for the synchronization of a timepiece to a reference time.

The invention provides a method of synchronizing a timepiece to a reference time, characterized by the steps of:

generating a first signal;

transmitting said first signal;

receiving said first signal;

composing a second signal consequent upon receipt of said first signal, said second signal including information relating to the precise time of receipt of said first signal;

transmitting said second signal;

composing a third signal consequent upon said first and/or said second signals being tested to determine whether said timepiece is displaying accurate time; and

transmitting said third signal.

The invention also provides a system for synchronizing a timepiece to a reference time, including:

means for generating a first signal;

means for transmitting said first signal;

means associated with said timepiece, said means being adapted to receive said first signal;

means composing a second signal consequent upon receipt of said first signal, said second signal including information relating to the precise time

of receipt of said first signal by said means associated with said timepiece;

means for transmitting said second signal;

means for composing a third signal consequent upon said first and/or said second signals being tested to determine whether said timepiece is displaying accurate time; and

means for transmitting said third signal.

A method of synchronizing a timepiece to a reference time has also been suggested, which includes the steps of:

generating a signal which includes information relating to said reference time;

transmitting said signal from a transmitter;

receiving said signal at or in the vicinity of said timepiece;

processing said signal to enable said timepiece to display a time, or generate an output representative of said time, said time being the correct time for a preset zone, locality or offset.

Apparatus for synchronizing a timepiece to a reference time has also been suggested, which includes:

means to receive and decode a transmitted signal, said signal including information relating to said reference time;

means to extract from the decoded signal information relating to the correct time for a preset time zone, locality or offset; and

means to display or to output said correct time.

A timepiece adapted to be synchronized to a reference time has further been suggested, which includes:

receiver means adapted to receive a signal containing time zone data for a plurality of time zones;

control circuitry for decoding said signal; and

locality switch means for selecting one of a number of predetermined time régimes;

such that said circuitry sends to a display, or to other apparatus, a time signal representative of the correct time for the selected predetermined time régimes.

A timepiece adapted to receive and decode a signal containing time zone data for a number of time zones, and data on daylight saving changes has also been suggested, which includes:

means to store said data on daylight saving changes so that the time alteration consequent upon said changes may be effected for that timepiece on a stated time and date, even if no further signal is received.

A method of setting a timepiece in accordance with a signal containing data on daylight saving time changes has also been suggested, which includes:

transmitting said signal;

receiving said signal at or in the vicinity of a timepiece;

decoding said signal;

storing said data; and

setting, at a time and on a date contained in said data, said timepiece to a new time.

A method of synchronizing a timepiece to a reference time has further been suggested, which includes the steps of:

generating a signal which includes information relating to said reference time;

transmitting said signal from a transmitter;

receiving said signal at or in the vicinity of said timepiece; and

processing said signal to enable said timepiece to display a time, or generate an output representative of said time, said time being the correct time for a preset zone, locality or offset.

Apparatus for synchronizing a timepiece to a reference time has also been suggested, which includes:

means to receive and decode a transmitted signal, said signal including information relating to said reference time;

means to extract from the decoded signal information relating to the correct time for a preset zone, locality or offset; and

means to display or to output said correct time.

A method of synchronizing a timepiece to a reference time has further been suggested, which includes the steps of:

generating a signal which includes information relating to said reference time;

transmitting said signal from a transmitter;

receiving said signal at or in the vicinity of said timepiece; and

processing said signal to enable said timepiece to display a time, or generate an output representative of said time, said time being the correct time for a preset zone, locality or offset.

Apparatus for synchronizing a timepiece to a reference time has also been suggested, which includes:

means to receive and decode a transmitted signal, said signal including information relating to said reference time;

means to extract from the decoded signal information relating to the correct time for a preset zone, locality or offset; and

means to display or to output said correct time.

A method of synchronizing a timepiece to a reference time has further been suggested, which includes the steps of:

generating a first signal;

transmitting said first signal;

receiving said first signal;

composing a second signal consequent upon receipt of said first signal, said second signal including information relating to the precise time of

receipt of said first signal; and

transmitting said second signal.

A system for synchronizing a timepiece to a reference timepiece has also been suggested, said system including means connected to a transmitter, said transmitter being adapted to transmit a first signal to a timepiece, said means being adapted to receive said first signal and to compose a second signal including information on the precise time of receipt of said first signal, said second signal being adapted to be transmitted by said transmitter.

A system for synchronizing a timepiece to a reference time has further been suggested, said system including:

means to generate a first signal;

transmission means to transmit said first signal;

monitor means connected to said monitor means for receiving said first signal and for composing a second signal related to said first signal, said signal thereafter being transmitted by said transmission means; and

means associated with said timepiece for commencing a count and receipt of said first signal, and for using the information from said count and from information contained in said second signal to generate accurate time.

A method of synchronizing a timepiece to a reference time has also been suggested, where a signal is transmitted to said timepiece to enable to time kept or displayed by said timepiece to be synchronized to a reference time, the step of including additional information, when received by a timepiece, results in a predetermined message or the like being displayed.

Embodiments of the invention, which may be preferred, will be described in detail

hereinafter with reference to the accompanying drawings, in which:-

Fig 1. is a block diagram of a method and apparatus for synchronization of a timepiece to a reference time;

Fig 2. is a block diagram of the signal generation and transmission aspect of the arrangement of Fig. 1; and

Figs. 3a and 3b are two parts of a circuit diagram of receiving/decoding apparatus.

The block diagram of Fig. 1 represents an arrangement which utilises the Telstra Radio Paging Network (RPN). The RPN is adapted to send messages to paging devices carried by persons. Although at the present time the RPN does not service the entire area of Australia, it can reach some 90% of the population, and Telstra is committed to an expansion of the network. The network is currently operated by sending signals by landlines to master transmitters, which relay signals to a larger number of slave transmitters. In the future, signals may be transmitted from an Earth station to a geosynchronous satellite, which in turn will transmit the signals to the territory of Australia.

In networks such as the Telstra RPN, paging receivers (not shown) usually have an individual address commonly called a Cap.Code (CC), which allows a specific message to be sent to a particular paging receiver, which is the core business of such a network. However, if a single message is to be sent to a group of paging receivers, a common Cap.Code is used and a group call may be made that simultaneously conveys the information concerned to all the receivers in the group, which have that common Cap.Code.

Fig. 1 shows signal generating apparatus 10, which will be described in more detail in relation to Fig. 2. A signal – preferably an encoded and/or encrypted signal – will be prepared using apparatus 10, and then sent to the RPN signal distribution centre for transmission from the RPN transmitters. Such

transmissions could be made in a number of ways. The transmission could be a continuous transmission, or a periodic transmission during daylight hours, or at night. Preferably, the transmission would be arranged to take place in the early hours of the morning, when a paging network's normal load is at its lightest and as a result transmitting capacity for the time signal is readily available. The encoding/encryption of the signal is necessary to ensure that unlicensed or non-accredited timepieces are not able to decode the signal for time correction and other operations. A decoding key may be incorporated as an integral part of electronic circuitry in a timepiece, or may be in the form of software. It may also take the form of a Smart Card.

The signal generated by apparatus 10, which includes a real time message, is sent to the RPN signal distribution centre 12. According to the chosen option amongst those already discussed, the signal is sent for transmission to a plurality of transmitters, two of which are shown at 14 and 16. Although it is envisaged that each of the transmitters will transmit the same signal at the same time, it is quite likely that transmitters will send signals at different times. However, each transmitted signal will be a real time signal. Such transmitters are, as discussed previously, normally used to transmit signals which are adapted to be received by paging devices (not shown). Timepieces 18 and 22 are located remotely from transmitters 14 and 16, but each is in range of at least one transmitter. It may well be that timepiece 18 is in the Western Standard Time zone, and timepiece 22 is in the Eastern Standard Time zone.

Timepieces 18 and 22 preferably include a radio receiver and control circuitry (shown in Fig. 3), such that a time message signal transmitted from transmitter 14 or 16 is received by the receiver and decoded by the control circuitry to synchronize a clock mechanism in the timepiece to adjust the mechanism to the correct time. The clock may have an analog display (20) or a digital display (24). Alternatively, the output from the control circuitry may consist of output means such as a digital signal, which may be directly or indirectly interfaced to a personal computer, slave clocks, cash register or other electronic equipment for the purpose of conveying correct time and/or time synchronizing, which may also

include year, day and date information.

The clock mechanism's circuitry may be so arranged that the time (and the day, date and year information if they are included) is able to be synchronized as a result of receiving the aforementioned signal to maintain the accuracy of the mechanism, or for updating the time for changes such as the entry into or the departure from Daylight Saving, or for the occasional corrections to UTC (Co-ordinated Universal Time) time. As far as the latter is concerned, there are regular agreed corrections to time, often by the addition of a leap-second on a predetermined date. While UTC time - which is equivalent to Greenwich Mean Time - is referred to throughout the specification and claims, local time, which is in itself derived from UTC time, may well be substituted when accurate time is being sourced, and any reference to UTC time may be seen to include local time.

In Fig. 1, timepiece 18 is, or is connected to, an analog clock whose display shows that the time is 10:07 Western Standard Time. In the preceding twenty-four hours, a signal has been received from transmitter 14 or 16 to correct the time on the display. Timepiece 22 is associated with a digital display, which shows the time to be 12:07:41 EST. It also has received a signal within the last twenty-four hours to correct the time.

There are many variations to the basic scheme described in relation to Fig. 1. The time transmissions from transmitters 14,16 could be specific to a particular time zone. Thus, transmitter 14, located in Western Australia, and all other transmitters in that time zone, could transmit a signal which related only to the Western Standard Time zone. Transmitter 16, located in the EST area, and any other transmitters in that zone, may only transmit a signal relevant to that zone. Of course, for other areas of the world, a single time zone may include a number of countries.

However, the preferred approach would be to have a common signal transmitted from all transmitting sites within the region concerned, which in the Australian

context means the whole country. Such a signal would contain a message giving the correct time for all time zones in the region, and would also include a code which would allow a decoding device to assign the correct time to the correct locality code so that when the time message is received and decoded the correct time for the particular time zone is determined.

As a preference, the device would include a switch or a series of switches which could be termed "locality switches". The locality switch could be set to program the time transmission decoder in the radio clock mechanism to keep the time for any locality included in the information transmitted by the signal. In normal use the switch would be set to the position for the time zone in which the clock mechanism is located. However, by setting the switch to another position, a display of the time in another zone may be obtained. A permanent setting of the switch to another zone – a zone anywhere in the world – would be useful in locations where it is desired to know the time in that zone. Applications could be at airports, in financial dealers' offices and the like. In addition, in a place such as Broken Hill, which despite being in New South Wales has historically operated on Central Australian Time, a timepiece locality switch could be set to CST. This would be accomplished by comprehensive information being included in time signal transmissions. A locality switch may take the form of a single multi-position switch, a series of switches, a push-button arrangement, or software means.

Some persons like to operate with a clock which displays a time which is in advance of the correct time. For example, a person may wish to have a clock which is five minutes ahead of the actual time. Means may be provided such that the clock mechanism may display, instead of the correct time for a zone or locality, a time which is in advance or in retard of that time. It may be possible to select such an alternative display by providing one or more settings on the locality switch.

Fig. 2 is a block diagram in more detail of the transmission part of the approach of Fig. 1. A source 26 of accurate time, for example an atomic clock or an on-

line modem feed of correct time, which is commercially available, provides an output to a modem interface 28, which in turn outputs to a master time encoder 30. A personal computer interface 32 also outputs to master time encoder 30, and controls the preparation and output of the encoded signal to the RPN 12.

The master time encoder 30 produces an encoded and encrypted real time message containing, apart from the Cap.Code applicable, an identity code (ID), UTC time accurate to within 100 milliseconds or better, the digital inverse of the previous UTC time, UTC date (with year, day of year, day of week, day of month and month of year redundant coding, date of next (if any) leap-second update, and time zone data consisting of data for a plurality of time zones, for example up to sixteen time zones made up of the time for each time zone in plus or minus desired intervals from UTC time, together with date (if any) of the next Daylight Saving change and the direction of that change for that time zone. The digital inverse of the previous UTC time is sent as well as real time UTC, to enable a comparison of the two pieces of information to be made by control circuitry at the timepiece, as a monitoring and checking measure. A preferred interval from UTC time may be 30 minutes, as throughout the world most if not all time zones are reckoned in half-hour or hour intervals from UTC time. It is preferred that a single signal, containing time zone data on sixteen time zones, be transmitted. Although at present there is only a maximum of eight time zones in place in Australia during any one period, should other areas be covered, the signal would have the capacity to service those areas.

Information on the next Daylight Saving change(s) is sent in advance of the earliest date, to enable the timepiece to reset the time, even if it does not receive a regular signal immediately after the change, or the preceding few signals. the information includes at least the date on which the change is to occur, and if required the time of the change, together with the direction and magnitude of the change. Such Daylight Saving information may be routinely transmitted as part of each signal transmission, and may be stored by the timepiece and used by it to automatically effect the correct time adjustment for Daylight Saving when the real time in the timepiece corresponds to the time and date that has been

routinely conveyed to the timepiece and stored. Following the change of the time in the timepiece to or from the Daylight Saving time the signal format would be reconfigured to routinely include information about the next correspondence between real time and the Daylight Saving time change required time for the purpose of changing the time at the correct Daylight Saving adjustment time.

By using such a system of sending information in advance on Daylight Saving changes, the requirement that the timepiece receive a specific signal transmission to initiate a Daylight Saving change is removed. Furthermore, the requirement that a Daylight Saving change signal be transmitted at a precise time to initiate the change is also removed. It follows that if for some reason a signal is not transmitted or received, such a change will still be made.

The real time generated time code signal is fed via a real time handshake system to the RPN 12 for broadcast through transmitter 14. The handshake takes the form of the master encoder requesting (A) the RPN for permission to feed data for transmission, an acknowledgment (B) from the RPN 12, and the feeding of data (C) from the encoder 30 to the RPN 12.

The format of the real time message to be transmitted may be:

<ID><Time></Time><Date><Leap-Second-Date><Time Zone Data>

The preferred manner in which it has been suggested that the time message signal is transmitted is for it to be transmitted six times within a twenty-four hour period, with intervals of about five minutes between each transmission. It is envisaged that the preferred single signal, containing real time data on 16 time zones, would transmit in about 4.5 seconds. Preferably, the first transmission would commence at around 02:00:30 EST. That enables the handshake to take place immediately after 02:00:00, and the protocols of that mean that transmission may commence within a few milliseconds, consistent with an immediate acknowledgment of the request.

The circuit of Fig. 3 is that of a "receiving clock mechanism" which may be regarded as a variant of timepiece 18 or timepiece 22 of Fig. 1. The mechanism consists of a conventional radio frequency pager "front end" receiving arrangement 34. The front end 34 provides either the raw POCSAG data or other data or decoded POCSAG message data to a microprocessor, microcomputer or similar processing unit. POCSAG is an acronym for the Post Office Code Standardization Advisory Group.

An input signal processing unit decodes the time data signal to reproduce the original time, date, leap-second date adjustment, time offsets to UTC time, the next Daylight Saving date, and the direction of change, for multiple time zones.

The time processing unit also receives external inputs at power up that instruct the processing unit what kind of output configuration to assume; examples are pulse, serial, LCD, parallel bus, master or slave. The time processing unit also receives inputs from a time zone or locality switch to set the time zone or time locality to which displayed and/or outputted times are to be set. A user adjustment inputs to the processor to allow for user setting of time, date and alarm time and date information. Time zone, time, date, alarm and other data may also be set and altered by means of software commands received by parallel or serial input means.

The processor maintains a real time clock mechanism synchronized with UTC time and date, derived from the decoded radio pager received signal. Initially the real time clock mechanism is set with the received time. For several days following, the real time will not be reset with the latest received time. Instead, the latest received time will be stored and an adjustment will subsequently made to the displayed and outputted times. Thus, the real time clock mechanism will be allowed to drift, and after several days an accurate calculation of the direction and magnitude of the clock mechanism's drift will be made. That will enable the mechanism to self-calibrate, even in the absence of a time message signal. It will accordingly be possible for manufacturers to produce cost-effective, reliable clocks which will maintain accurate time even in the absence of receiving a radio

time message signal for several days. This feature caters for the temporary lack of such a signal as a result of storm activity (thunderstorms causing electrical activity), power failure at the transmitter, temporary location of a timepiece in a location where it cannot be reached by a signal, temporary location of a timepiece out of range of a transmitter, and so on. In such circumstances it can also be seen that the practice of sending information on Daylight Saving changes well ahead of the earliest date for any of those changes, enables a timepiece to be reset to the new time régime even if it has not received a signal for some time.

Each timepiece, especially timepieces 22 having a digital display, may display, upon selection, the date and time of the next Daylight Saving change. In addition, a timepiece may show that it is in Daylight Saving mode. Furthermore, the display may indicate that the timepiece is out of range of a transmitter; a simple "Out Of Range" message would suffice. In addition, the display may also indicate that the displayed time is not accurate, when it has not been corrected for some time or at all, for whatever reason. It may be that the timepiece has never been in effective range, or log-term disturbances have prevented a good signal being received. In such cases, a message such as "Unreliable Time" or "Bad Time" would be shown.

An onboard clock mechanism memory will maintain time zone offset and daylight saving data (date and direction of changes), date, leap-second date, alarm mode, alarm time and date, time and oscillator adjustment constants, configuration mode, a history buffer of received time message radio signals, together with matching onboard real time clock time.

Time and date for the time zone selected shall be displayed and/or outputted and/or made available in one or more of several formats as selected by the configuration mode inputs to the processor. Some possible ways in which outputting of the time and date may take place are as follows:

Pulses at one-second intervals for analog clocks. Such pulses may be

temporarily halted or fast stepped in order to synchronize an analog clock to real time. Output for one-minute or one-hourly pulses may also be provided. Reset output and "reset done" output provide the logic to reset the hands of the clock to a predetermined position.

An asynchronous serial communication output with or without a parity bit. Interfacing to connected electronics may be via TTL logic levels RS232, RS422, RS485, infrared or optical means.

A half-duplex asynchronous serial communications interface which sends time, date and other data upon a request from connected electronics. Interfacing to connecting electronics may be via TTL logic levels, RS232, RS422, RS485, infrared or optical means.

LCD display attached either directly or via LCD display driver electronics.

Parallel bus outputs.

A parallel bus interface which sends time, date and other data upon a request from connected electronics.

The processor also checks for errors in received radio pager data, loss of RF signal, low battery voltage and the lack of radio time update after several days. Errors are indicated by several output signals including buzzer, low power, out of range and data error, and/or by status register accessible in half-duplex serial mode or parallel bus mode, or errors may be indicated in several ways on the LCD display.

The circuitry of the module operates as follows when the unit is first powered up. When power is applied, for example when a battery is inserted, the unit will stay in a powered up mode until time message signals are received, subsequently powering off until the next transmission is due. If, however, the timepiece is manually set after initial power up, it will then power off until the next signal

transmission is due. The unit is provided with a battery-saving capacitor, such that if a battery is replaced within about a minute of removing the old one, the unit will not behave as if it has been powered up.

A power management unit within the processor keeps power usage to a minimum. This is considered to be of importance in the marketing of any battery-powered timepiece. It is intended that any such timepiece would have a life of at least a year, before battery replacement is necessary. It follows that power usage must be kept to a minimum. The radio pager front 34 is powered off except for an average of 12 minutes per day between 02:00:00 and 02:25:00. This is accomplished by a polling facility. The front end is powered up daily to receive the group of signals. If a predetermined number of good signals in a group is received (for example, two good signals in a group of three signals, or three in a group of six signals) the front end will power off, not being required to deal with any subsequently-transmitted signal. In general, electronics not in active use are powered down.

The processor also maintains a watchdog timer. When the analog clock mode is not being used or half-duplex serial or parallel bus modes are in use, then unless a valid input from connected electronics other than front end 34 within a given time period (for example 25 hours) then a reset output is pulsed high or low in order to reset external mechanisms or electronics. A valid input is either a pulse input of defined maximum duration limits to the "reset done" input, or a valid software input command on either the parallel bus or serial inputs.

The module of Fig. 3 is adapted to form the core of a radio pager clock. Among the many variations on the basic theme of a radio pager clock, one may find analog clocks, LCD, LED and mechanical flip panel wall, desk and bedside clocks, clock plug-in boards for PCs, clocks which connect to a PC via the keyboard connector, RS232 serially interfaced time for general use and connection to computers, and clock units on a RS485 bus. Apart from taking the form of a plug-in circuit board for insertion into a vacant slot in a PC, the module may be incorporated into a separate stand-alone unit which is connected to one

of the communications ports of the PC or adapted to be wired into the PC circuitry or included as an integral part of the PC circuit board design. Software may also be installed on a PC for the purpose of having the PC internal clock slaved to the time message signal to maintain correct time and date.

It is envisaged that reference timepieces will be located at particular locations, so that transmission delays may be adjusted for. Clearly, there will be measurable and differing delays between the generation of a particular signal and the receipt thereof by a timepiece. The reference timepieces, which may be located in each transmitter head, would be used to quantify particular delays so that a compensatory adjustment could be factored into the signal. If the paging network transmitted from a geosynchronous satellite, path differences to different places in Australia would be negligible, and it may then be able to make a single signal adjustment.

Among the applications of the time synchronized timepiece of the present invention, one may envisage a digital time display on a pager, in a motor vehicle, as a part of a wristwatch, as part of airconditioning controls, security entrance controls, as part of time-locks for safes, on telephones and in elevators.

Modifications which have been envisaged include the use of single or multiple transmitters in and around Australia, the use of TV and/or AM, FM and shortwave radio transmitters. The time message signal may also be transmitted from a satellite.

Another embodiment of the present invention relates to the previously-described system using the Telstra Radio Paging Network, or a similar network. It is also applicable to any other suitable type of signal-transmitting infrastructure.

The approach has been to provide a 'real time' signal to enable timepieces to be synchronized to a reference time. It has already been acknowledged that true real time signalling is difficult if not impossible to achieve due to transmission delays, and for that reason the provision of monitoring apparatus in, on or near

transmitter heads is suggested as a way to adjust for factors such as the difference distances - and hence signal transmission times - between a transmitter and a number of timepieces.

In addition, there can be problems in the transmission of signals from a paging network. Generally, messages are sent to a network via a telephone system, and enter a queue. Depending on the number of messages already in the queue, there could be quite a delay before a time synchronization signal is transmitted. In both Australia and in other countries, it may not be technically feasible to 'queue-jump' with a time synchronization signal. Even if it were possible, some paging network operators may not be prepared to allow queue jumping. After all, their main business is the transmission of messages to paging devices.

One embodiment of this invention attempts to overcome such problems by providing a monitor within transmission range of a transmitter which monitor is adapted to receive signal transmissions from that transmitter head. The monitor is preferably connected in some way to the transmitting network, and to be able to send a message on the network. A monitor may be physically placed at the transmitter site, or alternatively, could be connected via a link such as a modem, with a known fixed delay.

In its simplest form, the embodiment envisages transmitting a first signal, which may be regarded as a start signal or 'mark'. That first signal or mark would be sent to the paging network as generally described earlier in this specification, and may well wait in a queue before being transmitted. A typical queue delay may be about five minutes.

The receipt of the mark signal by a timepiece would start an internal counter within the timepiece. The signal is also noted by the monitor, which is in the transmitting coverage area of the transmitter. The monitor notes the precise time the first signal (mark) was received by it. The monitor would then compose a second signal which includes information on the precise time of receipt of the

first signal. That second signal would then be sent to the transmitter for transmission. A timepiece, on receiving the second signal would apply that precise or accurate time sent by the second signal to the elapsed time on the counter, to provide an extremely accurate time or display on the timepiece or in any other way already envisaged by this specification.

The second signal may be sent at any time after the first signal, the only limiting factor being a desire to limit battery use in a timepiece. It is quite unlikely in any paging network that a delay of more than five minutes would occur between the generation of the first signal and its transmission. It is accordingly suggested that in this embodiment each timepiece should be gated "on" for about ten minutes, each time a transmission is expected.

By way of example, a first signal could be sent at four times in each 24-hour period, including a preferred transmission around 2:00 am local time to cater for Daylight Saving changes, as discussed earlier in this specification.

Some, or each first signals could be a simple signal, or a mere mark, or could include all of the information (and more) which signals, previously discussed in this specification, have. Regardless of the content of the first signal, each second signal would have to contain at least the precise time information referred to earlier.

A preferment could involve a first signal being a simple, short signal, with the corresponding second signal containing all other necessary and/or desired information. The second signal, each signal, or the first signal, could contain additional information.

Paging transmitters tend to be arranged in groups to cover various localities. For example, the greater Melbourne area may have five transmitters. They may all send their time synchronization signals at the same time. However, transmissions in the Gippsland area of rural Victoria may be unrelated in time to those for the Melbourne area.

There may be a circumstance were a mobile timepiece moves between different areas during the period between a first signal (mark) and a second signal. Such a timepiece may receive a "Melbourne mark" and a "Gippsland second signal" or correction. The timepiece would end up with an incorrect time. To avoid such a circumstance, each group of transmitters may include an identification code with each transmission, so that correct first signals may be correlated with correct second signal corrections/calibrations. The use of such a "tag" in an ID code would prevent the mis-application of a correction to the wrong area, and ensure that the applicable correction for the area in which the timepiece is located, would be made. This also applies to a fixed timepiece which may receive signals from a transmitter located in, or broadcasting to, a different area.

It is envisaged that with this non real time variant, Daylight Saving pre-alerts would still be included in each group of transmissions so that even if a timepiece does not receive its message at 2:00 am local time on the appropriate day it will still already correct the time on the correct date.

As has been stated some or all and/or additional information, to that discussed in general earlier in this specification, may be included in one or both signals. Such things as the pre-alert Daylight Saving correction and the date are included in that information, as is the facility for time zone data for a plurality of time zones to be included in a signal transmitted in one time zone.

In a method of transmitting a signal used to synchronize a timepiece to a reference time, in accordance with this invention, particularly in relation to the embodiment in which the signal is sent via a paging network, the signal may contain additional information, such that that additional information, when received by a timepiece (18,22) or the like, results in a message being displayed on the timepiece or elsewhere, or another function of or associated with the timepiece may be controlled.

For example, the signal may contain information which enables a particular message to be displayed on all timepieces (18, 22), or only on those in a

particular time zone or a particular grouping, or only on a specific timepiece. In that manner, a message containing information which is of personal or general application, such messages as advertisements, weather forecasts or warnings, news flashes – or birthday greetings – could be sent via the system, and displayed on the timepiece display. Such a display may utilise the existing alphanumeric display of a timepiece displaying digital time, or may involve the adaption of, or addition to, any display to represent an alphanumeric message. It may be that in any signal containing such a message, the information relating to the time may be omitted, although it would be advantageous in always including time update information.

As has been stated, each timepiece may be individually addressable. This may be achieved by the use of multiple Cap.Codes, typically four, for each timepiece, receiving clock mechanism or the like, each of which would be individually addressable. In that way, there would be a plurality of ways in which a given population or the like could be signalled, including the individual addressing of each timepiece.

For example, a particular timepiece may have a second, unique, Cap.Code which could be addressed with a message for its owner. Such a message could be a birthday greeting, a reminder or the like, which would be displayed on the timepiece as previously described.

Alternatively, a signal sent in accordance with this invention may contain, in addition to previously-described information, an internal address within the signal format, by way of a sub-address beyond a common Cap.Code, so that even though all timepieces (18,22) or the like with that CC receive the signal, only the group of timepieces, or an individual timepiece, with the appropriate internal individual and/or group address will respond in some predetermined manner. It may be considered convenient for the serial number of a timepiece to be utilised in the creation of an individual address.

One application of the individual addressability of a timepiece (18,22) is to

remotely enable or disable a function of the timepiece. It is envisaged that in practice, timepieces (18, 22) in accordance with the present invention will be subjected to service agreements which involve a periodical fee being paid by a person in return for which service for the timepiece will be provided for that period.

In order that such fees are paid, it may be necessary for the timepieces to be provided with means to enable each one to be individually disabled and enabled. Accordingly, it would be possible, should the fee not be paid for a particular timepiece, for a or the signal to contain information which causes that timepiece to be disabled, such that it could no longer receive (or display) time updates, and/or any additional messages or the like. In the event that the fee is subsequently paid, the or a signal may include information which results in the timepiece being enabled. The enabling and disabling may be effected by the relevant part of the signal acting to set bits in a timepiece (18, 22) or the like.

The enable/disable facility may be utilised in relation to any service taken by the timepiece or the like. For example, a person may subscribe to two services, such as time updates and weather messages, but may be in default in relation to periodical payments on only one service. The enable/disable facility may be used to switch off access to the facility for which payment is in default. Similarly, a new subscriber to a service may have the appropriate service enabled on the timepiece in question, subsequent to a first service payment. The enable/disable facility may be used to switch on and off any service to a timepiece or the like.

It should also be noted that in the event that in any jurisdiction there was a change in time zone policy – such has been discussed in South Australia, with a suggested move to Eastern Standard Time – it would be possible in accordance with this invention to download a software set to a timepiece, to cater for such a policy change.

One desirable form of unit capable of rapid deployment in a particular area for the provision of signals according to this invention transmitted via a paging

network is a "Paging Time Master Generating Unit". Such a unit, which could be located in a box or in something like a suitcase, would preferably include a computer such as an IBM-compatible PC, a modem which is adapted to communicate with the paging network and with a telephone network for providing faxed error reports and the like, a monitor for receiving signals broadcast from a paging network transmitter, and a source of accurate time.

Such a unit may be easily located on or in the vicinity of a transmitter, and with minimal connections may commence the transmission of timepiece-synchronizing signals in accordance with this invention. The computer, which of course is run on proprietary software, receives data from the transmitter, and also accurate time. The latter may be obtained from an atomic clock which may also be included in the unit, but it is more convenient to obtain accurate time via the modem from an on-line time service such as Telstra's Compuline.

The unit carries out the method of this invention as described in this specification, and connects with the paging network, preferably through a dial-up connection using the modem. With the Paging Time Master Generating Unit, and with some timepieces adapted to be synchronized in accordance with the invention, it would be possible to go to a particular time zone, and/or a particular country, and start a time synchronization system virtually immediately.

Clearly, a system other than a paging network could be used. For example, signals could be sent on a television or radio network. However, paging networks are more suitable, as they are geared to be a telephone messaging service.

Preferably, timepiece hardware and/or software would be able to operate with both real time signals and with the arrangement envisaged by the present invention.

Embodiments of the invention are suggested to cope with the possibility, however unlikely it may be, of data being inadvertently corrupted in the time transmitting

means or encoding means within the RPN, which may result in all timepieces receiving the corrupted signal and accordingly displaying a corrupted and thus incorrect time.

One embodiment envisages the timepieces which receive the time signal mark and update do not accept the data contained therein until a third, "confirmation" signal is received. Such a third signal is sent out over the RPN after a master unit located in the RPN coverage area, and having an accurate source of time such as an accurate real time clock, receives the time update and determines that the updated time is correct. If the tested time is correct, a "confirm" signal is sent to all timepieces.

Alternatively, if the master unit determines that the updated time is incorrect, an "ignore" signal is sent out over the RPN, as a result of which the timepieces do not accept the time as correct. During a predetermined time period, for example 15 minutes, after receipt of the update signal, the timepieces do not accept the time sent as correct, while the "ignore" signal is being sent out over the RPN.

The claims form part of the disclosure of this specification.

CLAIMS

1. A method of synchronizing a timepiece to a reference time, characterized by the steps of:

generating a first signal;

transmitting said first signal;

receiving said first signal;

composing a second signal consequent upon receipt of said first signal, said second signal including information relating to the precise time of receipt of said first signal;

transmitting said second signal;

composing a third signal consequent upon said first and/or said second signals being tested to determine whether said timepiece is displaying accurate time; and

transmitting said third signal.

2. A method according to claim 1, characterized in that said third signal, if said test indicates that accurate time is displayed, is a "confirmation" signal.

3. A method according to claim 1, characterized in that said third signal, if said test indicates that accurate time is not displayed, is an "ignore" signal.

4. A system for synchronizing a timepiece to a reference time, including:

means for generating a first signal;

means for transmitting said first signal;

means associated with said timepiece, said means being adapted to receive said first signal;

means composing a second signal consequent upon receipt of said first signal, said second signal including information relating to the precise time of receipt of said first signal by said means associated with said timepiece;

means for transmitting said second signal;

means for composing a third signal consequent upon said first and/or said second signals being tested to determine whether said timepiece is displaying accurate time; and

means for transmitting said third signal.

5. A system according to claim 4, characterized in that said third signal, if said test indicates that accurate time is displayed, is a "confirmation" signal.

6. A system according to claim 4, characterized in that said third signal, if said test indicates that accurate time is not displayed, is an "ignore" signal.

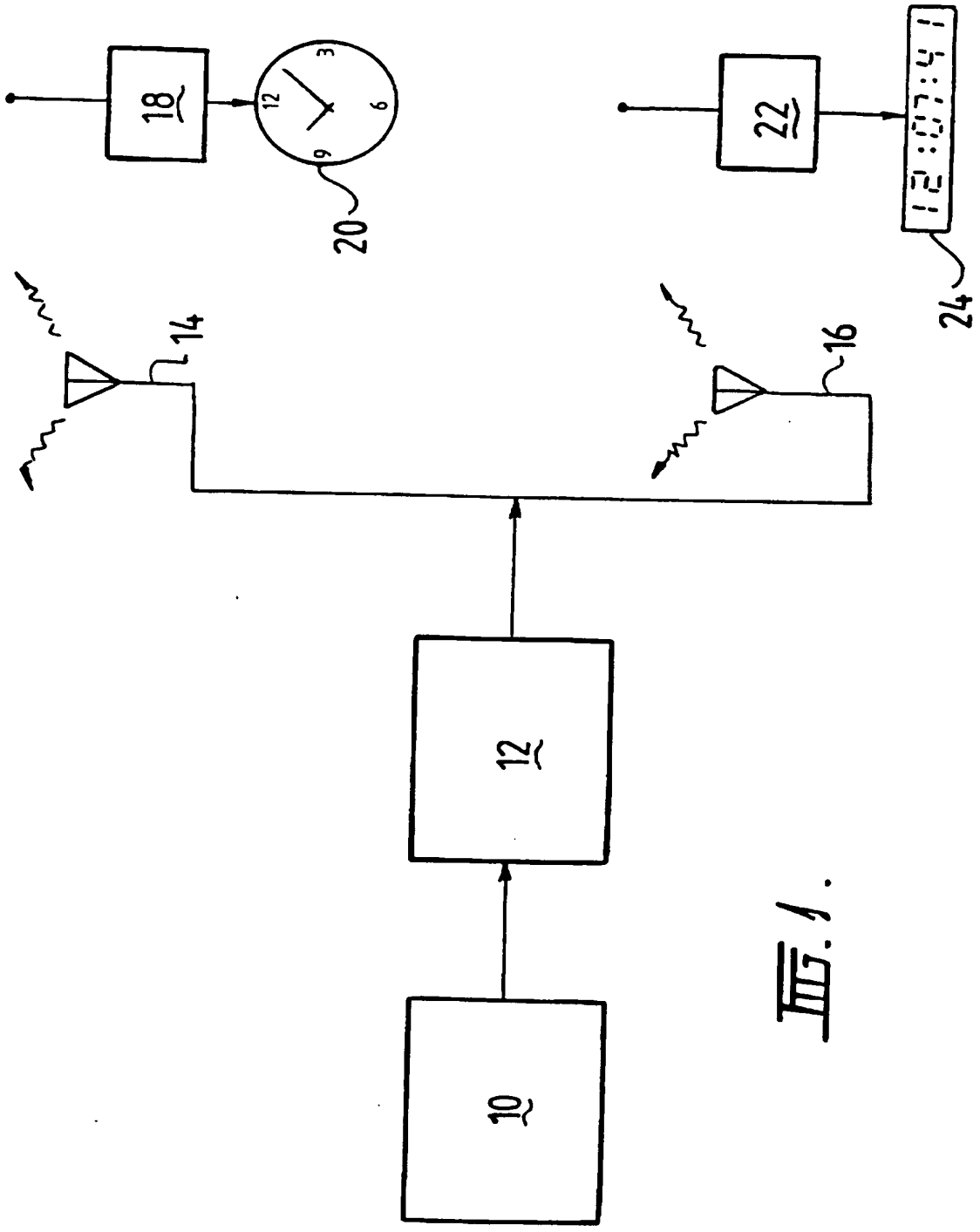

Fig. 1.

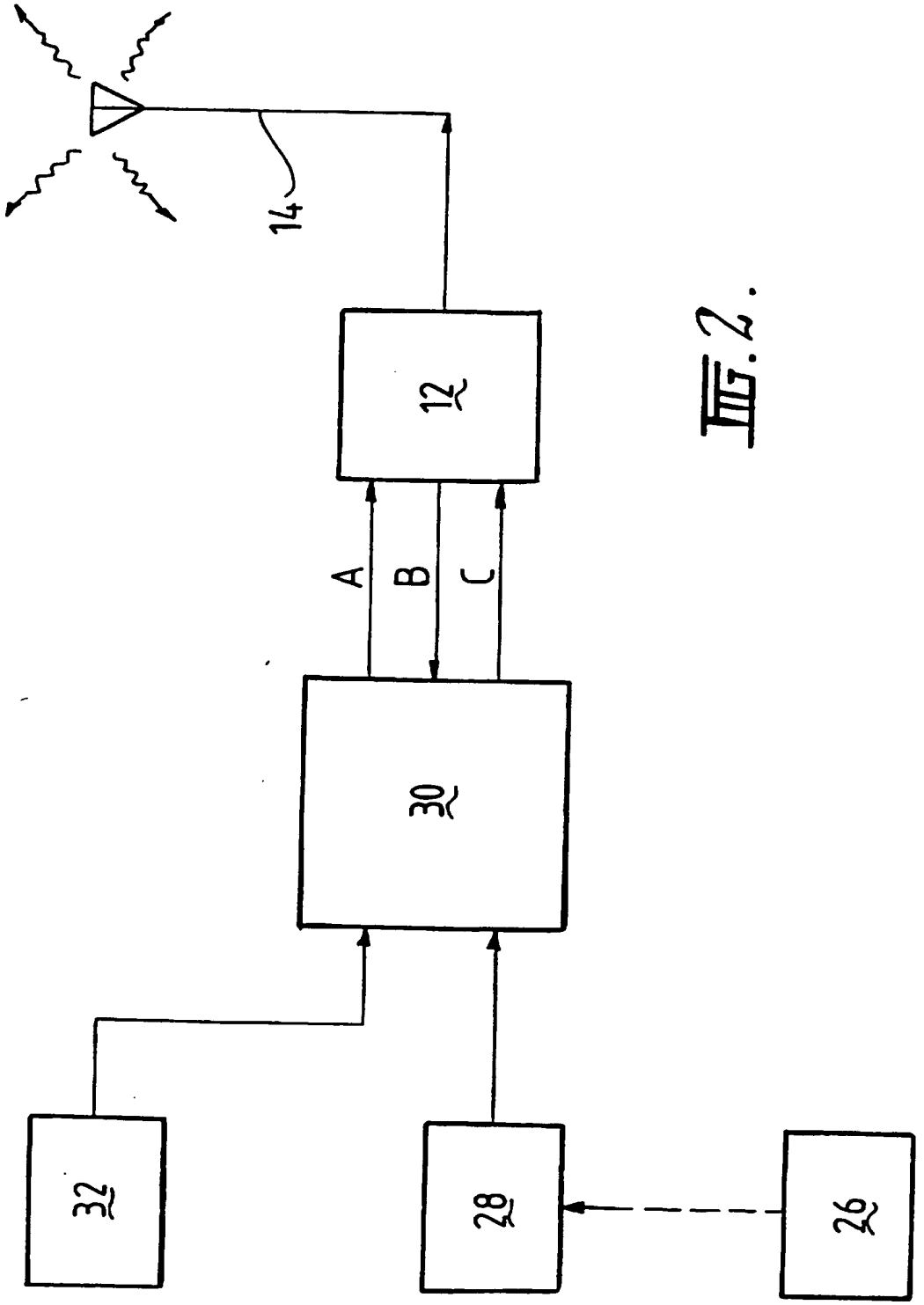

FIG. 2.

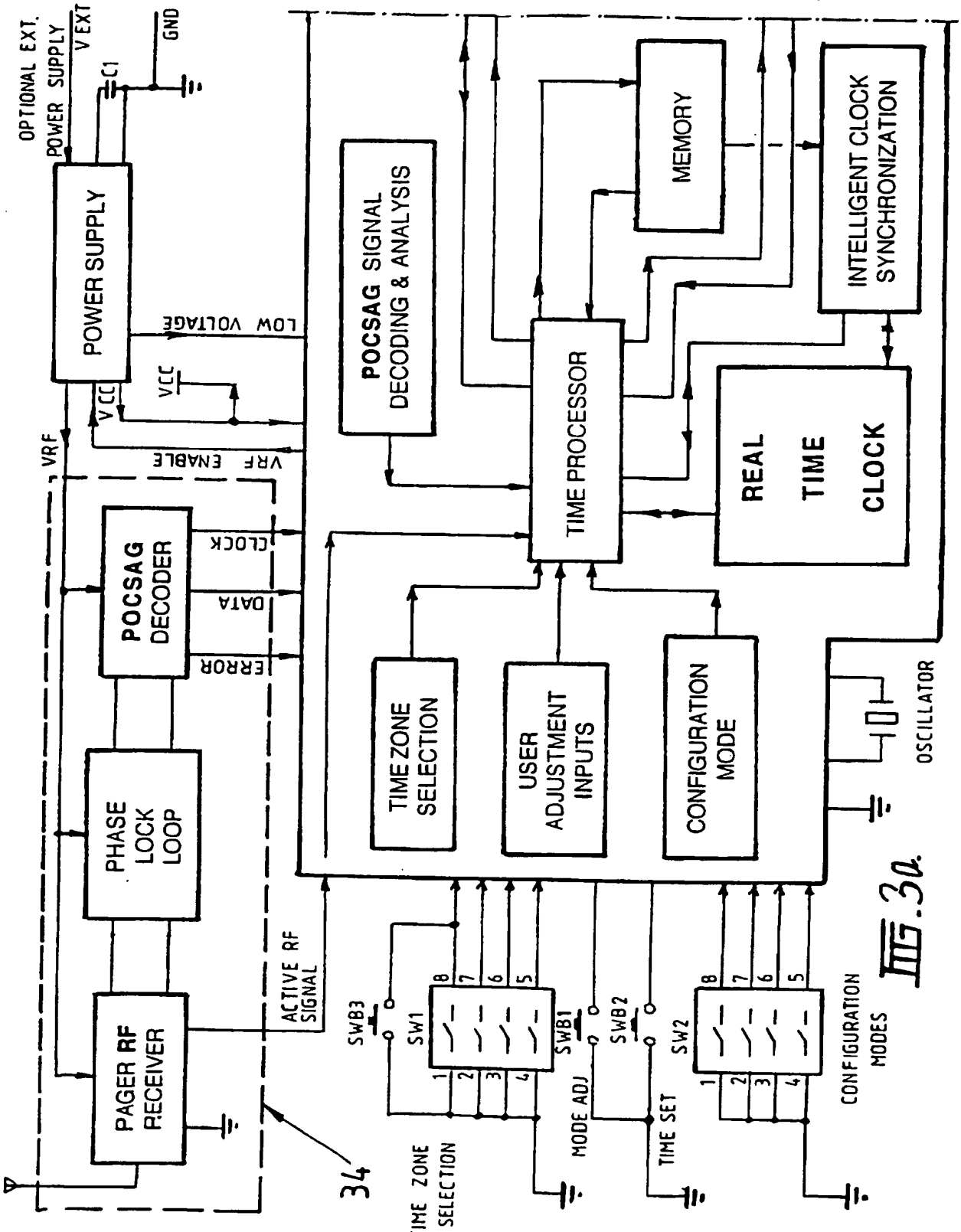
OPTIONAL EXT. POWER SUPPLY
V EXT
GND
C1
POWER SUPPLY
LOW VOLTAGE
VCC
VCC
VRF
VRF ENABLE
POCSAG DECODER
CLOCK
DATA
ERROR
PHASE LOCK LOOP
PAGER RF RECEIVER
ACTIVE RF SIGNAL
34
POCSAG SIGNAL DECODING & ANALYSIS
MEMORY
INTELLIGENT CLOCK SYNCHRONIZATION
TIME PROCESSOR
REAL TIME CLOCK
TIME ZONE SELECTION
USER ADJUSTMENT INPUTS
CONFIGURATION MODE
OSCILLATOR
SWB3
SW1
SWB1
SWB2
SW2
TIME ZONE SELECTION
MODE ADJ
TIME SET
CONFIGURATION MODES

FIG. 3a.

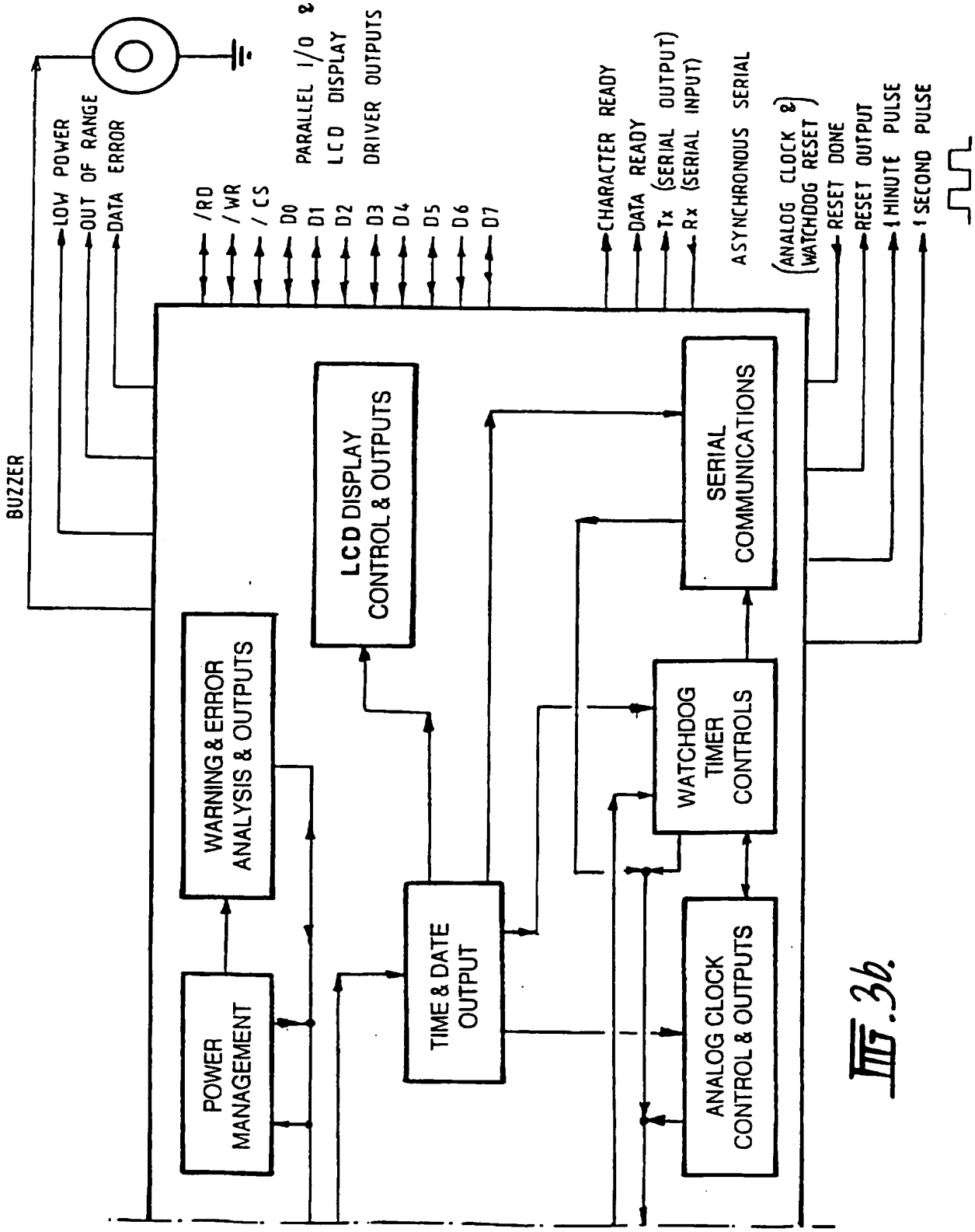
BUZZER
LOW POWER
OUT OF RANGE
DATA ERROR
/RD
/WR
/CS
D0
D1
D2
D3
D4
D5
D6
D7
PARALLEL I/O & LCD DISPLAY DRIVER OUTPUTS
CHARACTER READY
DATA READY
Tx (SERIAL OUTPUT)
Rx (SERIAL INPUT)
ASYNCHRONOUS SERIAL
(ANALOG CLOCK & WATCHDOG RESET)
RESET DONE
RESET OUTPUT
1 MINUTE PULSE
1 SECOND PULSE
LCD DISPLAY CONTROL & OUTPUTS
SERIAL COMMUNICATIONS
WARNING & ERROR ANALYSIS & OUTPUTS
WATCHDOG TIMER CONTROLS
TIME & DATE OUTPUT
POWER MANAGEMENT
ANALOG CLOCK CONTROL & OUTPUTS

Fig. 3b.

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 97/00659

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: G04G 7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC: G04G 5/00, 7/00, 7/02, G04C 11/00, 11/02, 9/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT: (G04G 5/00, 7/00, 7/02, G04C 11/00, 11/02) AND (SYNCHRONI: OR SET:) AND (TRANSMIT: OR SEND:)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO, 96/17278, A1 (GPT LIMITED) 6 June 1996 Abstract	
A	EP, 565180, A2 (PHILIPS ELECTRONICS UK LIMITED) 13 October 1993 Abstract	
A	EP 564220, A2 (GLENAYRE ELECTRONICS, INC) 6 October 1993 Abstract	

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 November 1997	21 November 1997
Name and mailing address of the ISA/AU AUSTRALIAN INDUSTRIAL PROPERTY ORGANISATION PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929	Authorized officer **I.A.BARRETT** Telephone No.: (02) 6283 2189

Form PCT/ISA/210 (second sheet) (July 1992) copjhw

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 97/00659

C (Continuation) **DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, 315028, A1 (FIRMA ERIKA KOCHLER) 10 May 1989 Abstract	
P,A	AU, 54723/96,(INTUITIVE SYSTEMS AUSTRALIA CORPORATION PTY. LTD.) 19 December 1996 Abstract	
A	AU 32854/55,(ETA SA FABRIQUES D'EBAUCHES) 4 April 1996 Abstract	
A	AU, 59372/94 (DIEHL GmbH & CO) 3 November 1994 Abstract	

INTERNATIONAL SEARCH REPORT
Information on patent family members

International Application No.
PCT/AU 9700659

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	9617278	AU	39866/95	EP	795147	GB	2296166
		ZA	9510100				
EP	565180	JP	6053888	US	5363377		
EP	564220	CA	2091962	CN	1082285	FI	931421
		US	5416808				
EP	315028	AT	96957	CH	670545	DE	3866334
		ES	2027364				
AU	59372/94	CA	2121552	DE	4313945	JP	7012966
AU	32854/95	BR	9504134	CA	2158693	EP	703514
		FI	954462	IL	115411	JP	8182034
		NO	953750	ZA	9507700		

END OF ANNEX